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A theropod dinosaur bone from the Late Cretaceous Molecap Greensand, Western Australia

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Abstract – A proximal pedal phalanx from a theropod dinosaur is recorded from the Late Cretaceous Molecap Greensand, at Gingin, Western Australia. It is only the second record of a Late Cretaceus dinosaur from Australia, and the first dinosaur bone recovered from the Perth Basin.

INTRODUCTION

Dinosaur remains are extremely rare in Western Australia. Only two bones have been previously recorded, a sauropod caudal vertebra from the Middle Jurassic Colalura Sandstone exposed at Bringo Cutting, near Geraldton, and a possible theropod humerus from the Late Cretaceous (late Maastrichtian) Miria Formation in the Giralia Range, south of Exmouth Gulf (Long 1992). In July 1992 a University of Western Australia Geology Department second year field excusion to the Molecap Quarry, at Gingin, discovered the third dinosaur bone from the state. The specimen, a small pedal phalanx, was found by student Michael Green and donated to the Western Australian Museum. The bone (WAM 92.7.1, Figure 1, 2 E–H) was found *in situ* in the Molecap Greensand at a height of about 2 metres above the quarry floor in the western face of the quarry. The age of the Molecap Greensand has been assessed as ranging from from Cenomanian to lower Turonian (Shafik 1990) to possibly Santonian (McWhae *et al.* 1958). To date the only other vertebrate remains recovered from the Molecap Greensand are chondrichthyan and teleost teeth, three mosasaur paddle bones (Lundelius and Warne 1960), and isolated plesiosaur and ichthyosaur bones and teeth (McNamara *et al.* 1993; Long 1993).

The only other bones of theropod dinosaurs described from Australia are all of Early Cretaceous age. An isolated theropod claw from Cape Patterson, southern Victoria, was described by Woodward (1906), and a caudal vertebra from Lightning Ridge was named as *Walgettosuchus woodwardi* by Von Huene (1932), although it is now regarded as a *nomen dubium* (Molnar 1991). A partial tibia and an isolated phalanx from Andamooka, South Australia, were identified as belonging to a new slender theropod called *Kakuru kujani* (Molnar and Pledge 1980). The Victorian outcrops of the Strzelecki and Otway Groups include an astragalus of *Allosaurus* sp. (Molnar *et al.* 1981), and undescribed vertebrae, jaw and limb bones from theropods, including ornithomimosaurs and a possible oviraptorid (Rich 1993; Rich *et al.* 1991, Rich and Vickers-Rich 1994).

The comparison made between the Gingin theropod and *Allosaurus fragilis* shown in Figure 2 is not to suggest that the Gingin specimen is here identified as *Allosaurus*, only to make the point that the specimen is a theropod with very close resemblances to *Allosaurus*. It is beyond the scope of this paper to compare phalangeal proportions of the known theropod dinosaurs with the Gingin specimen, only to record the specimen and make some general observations and comparisons.

DESCRIPTION OF THE SPECIMEN

The Gingin phalanx (WAM 92.7.1, Figure 1) is 40.8 mm in length, 25.7 mm proximal depth, 26.2 mm proximal width, 20.8 mm distal depth and 24.4 mm in distal width. The asymmetry of the distal articular condyles indicates it is from the left pes. The ventral surface shows the presence of a thickened platform of rugose bone close to the posteromedial corner (the flexor tubercle, shown arrowed in Figure 2 B, F) and the posterolateral corner has a slightly concave area of bone. The proximal face is relatively flat with only weak development of the articular ridges which received the distal face of the fourth metatarsal. In lateral view the ventral margin of the shaft of the bone is strongly concave, and the articular condyles of the distal end are well rounded and stand out prominantly from the neck of the shaft. The distal end of the phalange has well-defined, quite large collateral ligament fossae on each side.

The bone is well preserved and its characteristic proportions indicate that it is a pedal phalanx of a

theropod dinosaur by direct comparison with that of *Allosaurus fragilis* (Madsen 1976) and other theropods (casts and material examined by the author include *Tyrannosaurus, Tarbosaurus, Albertosaurus, Deinonychus, Allosaurus* and isolated ornithomimosaur pedal phalanges from the Judith River Formation, Alberta) differing from *A. fragilis* only by its smaller size and slight proportional differences, such as the depth of the proximal end (Figure 1 A, E). The phalanges of the manus in *Allosaurus* are all much narrower with more slender shafts than observed in the Gingin bone. In addition, a cast of the bone was shown to various dinosaur experts (Dr Philip Currie, Dr Peter Dodson, Mr Gregory Paul) in the U.S.A. at the Dino Fest Conference (Indianapolis, March 1994) who all commented that it appeared to be "an indeterminate theropod pedal phalange" bone .

In general the phalanges of ornithopods reflect their broader feet proportions in having wider phalanges with flatter dorsal and ventral surfaces. Direct comparisons were made with casts of *Muttaburrasaurus, Hypsilophodon, Saurolophus, Corythosaurus* and *Iguanodon*. Only the fourth digit proximal phalanx in *Allosaurus* has the same proportions as the Gingin bone in that the proximal face is relatively triangular in outline, much deeper than the distal end, and lacks a distinct vertical median crest (Madsen 1976, figs 54, 55).

The size of the Gingin bone is about half the length of the equivalent element in *Gorgosaurus libratus* (WA Museum cast of 1933 Sternberg specimen) and approximatly half the size of that in *Allosaurus fragilis*. Based on the adult sizes of these carnosaurs it is estimated that the Gingin theropod may have been about 4 metres maximum length.

Figure 1 Theropod pedal phalanx, proximal element of fourth digit, left side. WAM 92.7.1.Molecap Greensand (Late Cretaceous) , Molecap Quarry,Gingin, Western Australia. Specimens shown in A, dorsal; B, ventral; C, left lateral; D, distal and E, proximal views.

DISCUSSION

In its robust nature the specimen differs from the slender phalanges of advanced theropods like dromaeosaurids, oviraptosaurids, troodontids and

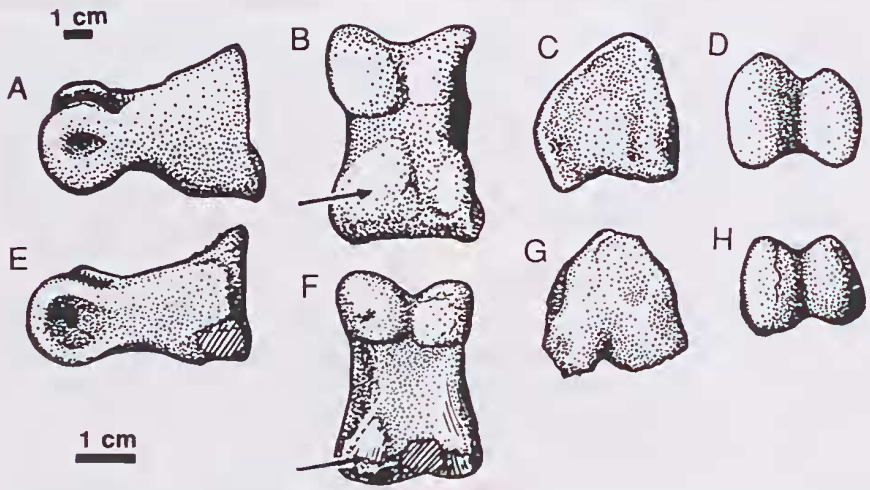

Figure 2 Comparison between the left fourth pedal proximal phalanx in *Allosaurus fragilis* (A–D) and the Gingin theropod (E–H). A, E, lateral views; B, F, ventral views, arrow points to flexor tubercle; C, G, proximal face; D, H, distal view of articular condyles. A–D after Madsen (1976).

ornithomimosaurs (Barsbold *et al.* 1990; Currie 1990; Barsbold and Osmolska 1990; Molnar *et al.* 1990; Osmolska and Barsbold 1990; Ostrom 1990) and appears to match most closely the generalised form of a carnosaur proximal pedal phalanx. Comparison with Late Cretaceous tyrannosaurids is precluded largely by the absence of published information on the phalanges, although a cast of the Sternberg skeleton of *Gorgosaurus libratus* from Alberta in the Western Australian Museum, and the author's examination of the American Museum of Natural History *Tyrannosaurus rex* skeleton, and of the mounted skeleton of *Tarbosaurus bataar* (touring Australia in 1993–1995 as part of The Great Russian Dinosaurs Exhibition) permits some observations to be noted.

In *Gorgosaurus* the fourth digit proximal phalanx is much more elongated and the ventral margin of the shaft is more stongly concave than for the Gingin specimen. In *Tyrannosaurus rex* and *Tarbosaurus bataar* the fourth proximal phalanx is of quite robust, short proportions and is comparable in general form with that of *Allosaurus* or the Gingin specimen, differing principally by their larger size.

Finally, one other theropod phalanx has a been described from Australia, an isolated element from Andamooka (Early Cretaceous, Aptian Marree Formation) refered to *Kukuru kujani* by Molnar and Pledge (1980). This specimen differs from the Gingin bone by its extremely slender shape with the distal and proximal faces of the bone being of approximately equal depth. Comparison with abelisaurids is difficult as few have shown preservation of the feet. The problematical theropod *Noasaurus*, from the Late Cretaceous of Argentina has one of the phalanges preserved. It is unusual in having deep flexor pits on the ventral surface rather than a flexor tubercle, and differs from the Gingin bone in this feature (Bonaparte and Powell 1980).

In summary, the small phalanx from the Molecap Greensand (WAM 92.7.1) is here referred to an indeterminate theropod dinosaur, most likely a member of the Carnosauria having similarities to the Allosauridae. The latest recorded members of this family are Aptian-Albian, from Australia (Molnar *et al.*1981), North America and Mongolia (Molnar *et al.* 1990). At this stage a determination to generic level is not possible until more theropod pes material is discovered.

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